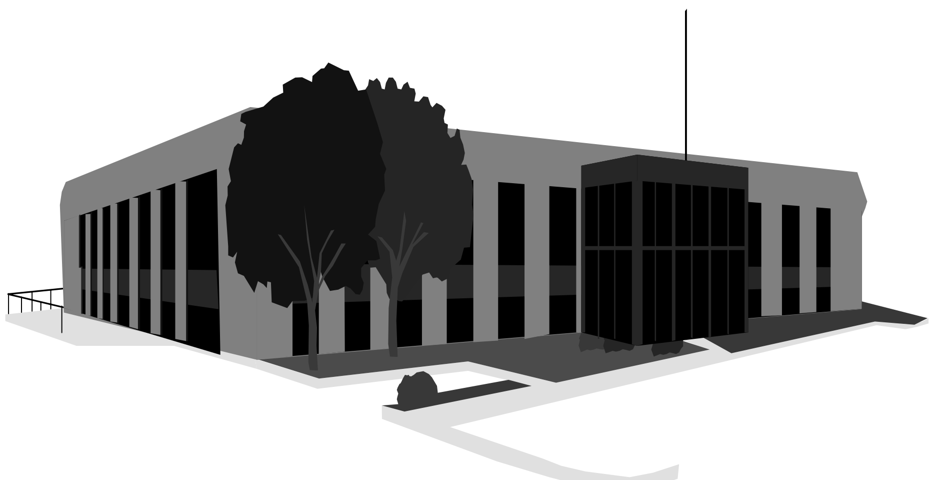
INDOOR AIR QUALITY ASSESSMENT

Undermountain Elementary School
491 Berkshire School Road
Sheffield, Massachusetts



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Bureau of Environmental Health Assessment
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Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality issues and health concerns at the Undermountain Elementary School, 491 Berkshire School Road, Sheffield, Massachusetts. On November 2, 2000, a visit was made to this school by Mike Feeney, Chief of Emergency Response/Indoor Air Quality, BEHA.

The original building was constructed in 1955 as a single-story, red brick structure. A wing was added in 1966. The building underwent renovations in 1993. These renovations installed hallways along original exterior classroom walls, resulting in the enclosure of windows indoors. The enclosed classrooms (e.g., the music room) are entirely dependent on mechanical ventilation for air exchange. The remainder of classrooms have openable windows. The school contains general classrooms, main administrative office, library, cafeteria, gymnasium, art room, and music room. The building is covered by peaked roof.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

This school has a student population of approximately 380 and a staff of approximately 50. The tests were taken during normal operations at the school. Test results appear in the Tables 1-4.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 ppm (parts per million) in twenty-three of thirty-four areas surveyed, which indicates an overall ventilation problem in this school. Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit (see Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. A number of univents were found to have been deactivated during the assessment. In addition, obstructions to airflow, such as cardboard, toys, boxes, plastic and magazines on top of or in front of univents were seen in a number of classrooms (see Picture 1). To function as designed, univents and univent returns must remain free of obstructions. Importantly, these units must be activated and allowed to operate.

Exhaust ventilation in classrooms is provided by a mechanical exhaust system. The exhaust vents are located along interior hallway walls of classrooms (see Picture 2). In some cases, classroom exhaust vents are located above wall-mounted cabinets. In one instance, the exhaust vent was blocked with a box stored on top of a cabinet. In order to function properly, exhaust vents must also remain clear of obstructions.

In order to have proper ventilation with a univent and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last servicing and balancing of these systems was not available at the time of this assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS. 1997, BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA. 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings recorded during the assessment ranged from 69 ^{o}F to 73 ^{o}F, which were close to the BEHA's recommended comfort range. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ^{o}F to 78 ^{o}F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Relative humidity measurements ranged from 28 to 37 percent, which were below BEHA comfort guidelines. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

In a number of classrooms, spaces between the sink countertop and back splash were noted. Water damage resulting in splaying of wood of sink areas was also noted (see Pictures 3 and 4). Repeated leakage or improper drainage/overflow can lead to water penetration of countertop wood, the cabinet interior and behind cabinets. If these porous materials become wet repeatedly they can provide a medium for mold growth. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). Porous materials that are not dried within this time frame may provide for mold growth.

Several rooms contained a number of plants, some of which were located near univents (see Picture 1). Plant soil and drip pans can also provide a source of mold growth. Plants should have drip pans to prevent wetting and subsequent mold colonization of window frames. Over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. Plants should also be located away from univents and exhaust ventilation to prevent the aerosolization of mold, dirt and pollen.

The greenhouse is designed to retain heat and moisture to aid the growing of plants. This room would have a higher relative humidity than other areas in the building. With increased exposure to moisture, porous materials (e.g., cardboard, wood, paper, ceiling tiles and cloth) can serve as potential media for mold growth (see Picture 5). Standing water was noted on top of a wooden table (see Picture 6). The use or storage of porous materials within the greenhouse should be avoided where possible to limit mold growth.

Other Concerns

Several other conditions that can potentially affect indoor air quality were also identified. Of note is the use of cleaning materials in classrooms. Cleaning materials frequently contain ammonium compounds or sodium hypochlorite (bleach-products), which are alkaline materials. The use of these products can provide exposure opportunities for individuals to a number of chemicals, which can lead to irritation of the eyes, nose or respiratory tract.

Classroom A4 contains several birds and rabbits. Debris from the interior of the bird cages was noted on tables (see Picture 7). Bird waste can contain a number of materials that are allergens. Rabbit dander, fur and wastes may also be allergenic to hypersensitive individuals. If animals are to be kept in classrooms, it is good practice to remove animal waste from cages frequently. In addition, cages of animals should be kept away from the air stream created during the operation of univents to limit aerosolization.

Some univent fresh air intakes are located at ground level (see Picture 8). These vents can be prone to drawing dust, dirt and pollen into univents. For this reason, grass cutting during school hours can present problems. They can also become blocked with accumulated snow.

Univents are normally equipped with filters that strain particulates from airflow. The filters provide filtration of respirable dusts. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent (Minimum Efficiency Reporting Value equal to 9) would be sufficient to reduce many airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increasing filtration can reduce airflow (called pressure drop) which can reduce the efficiency of the AHUs due to increased resistance. Prior to any increase of filtration, the univents should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters.

Conclusions/Recommendations

In view of the findings at the time of our inspection, the following recommendations are made:

1. Remove materials blocking univents and exhaust vents.
2. Examine univents throughout the school for function. Survey classrooms for air diffuser and exhaust vent function to ascertain if an adequate air supply exists for each room. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
3. Ensure that ground level fresh air intakes remain clear of blockages, particularly snow in winter. Avoid grass cutting during school hours.
4. Examine the filters in the univents and AHU and change these filters on a regular basis. Consider increasing the dust spot efficiency of filters to increase the removal of particulates from the environment.
5. Once fresh air supply and exhaust systems are functioning, consider having the systems balanced by a ventilation engineer.

6. Examine each sink counter top for water damage. Seal the back splash/countertop seam with caulking to reduce water penetration. Examine the floor below the water-damaged wood for mold growth. If mold is present, disinfect any non-porous surfaces with an appropriate antimicrobial agent and subsequently clean with soap and water.
7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, implementation of scrupulous cleaning practices to minimize common indoor air contaminants, whose irritant effects can be enhanced when the relative humidity is low, should be implemented. Among these methods can be the use of vacuum cleaning equipment outfitted with a high efficiency particulate arrestance filter (HEPA). Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
8. Remove plants from univent air stream. Ensure plants have drip pans. Examine drip pans for mold growth and disinfect areas with an appropriate antimicrobial where necessary.
9. Move animal cages away from univents. Clean cage materials from tables and disinfect tables with an appropriate antimicrobial agent daily. Clean nesting materials from the interior of cages frequently.
10. Store cleaning products and chemicals properly and keep out of reach of students.

References

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MGL. 1983. Hazardous Substances Disclosure by Employers. Massachusetts General Laws. M.G.L. c. 111F.

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

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Thornburg, D. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

Picture 1

Fresh Air Diffuser

Return Vent

Shelving And Plant Blocking Univent Return Vent, Fresh Air Diffuser Blocked With Poster

Picture 2

Classroom Exhaust Vent

Picture 3

Water Damaged Sink Countertop

Picture 4

Bowing Countertop Linoleum in Greenhouse

Picture 5

Cardboard and Other Porous Materials Stored in Greenhouse

Picture 6

Standing Water on Table in Greenhouse

Picture 7

Bird Cage Debris on Counter Outside of Cage

Picture 8

Univent Fresh Air Intakes Located Close to the Ground

TABLE 1

Indoor Air Test Results – Undermountain Elementary School, Sheffield, MA – November 2, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	437	56	32					
Main Office	660	72	31	5	No	Yes	Yes	Univent blocked by cardboard
B26	679	70	31	11	Yes	Yes		
A6	1257	70	36	12	Yes	Yes	Yes	Univent off, water damage-sink, refrigerator
A1	774	69	32	0	Yes	Yes	Yes	Univent blocked by cabinet, water damage-sink, plant
A2	980	69	34	12	Yes	Yes	Yes	Plants on/near univent
A3	1019	70	35	1	Yes	Yes	Yes	Boxes on univent, water damage-sink-mold, door open
A4	1137	71	35	13	Yes	Yes	Yes	Univent off, 8 birds-wastes, rabbits, water damage-sink
A5	919	72	33	14	Yes	Yes	Yes	Toys on univent, water damage-sink
A13	1028	71	33	16	Yes	Yes	Yes	Univent blocked by boxes, door open
A16	910	71	32	20	Yes	Yes	Yes	Exhaust blocked by box, water damage-sink

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Undermountain Elementary School, Sheffield, MA – November 2, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
A15	982	72	32	21	Yes	Yes	Yes	Univent blocked by boxes, clutter, door open
A14	731	71	32	2	Yes	Yes	Yes	Univent blocked by toys, window and door open, water damage-sink, clutter
A17					Yes	No	Yes	Window and door open,
A18	492	70	28	3	Yes	Yes (2)	Yes	1 out of 2 univent on, window open,
A19	689	71	29	8	Yes	Yes	Yes	Plants - table in front of univent, temperature complaints-cold
B42	1401	71	31	0	Yes	Yes	Yes	Water damage-sink
B43	811	70	30	10	Yes	Yes	Yes	Window open, water damage-sink
B37	895	70	32	10	Yes	Yes	Yes	Window open, water damage-sink
B36	575	69	29	0	Yes	Yes	Yes	Ammonia
B35	958	71	33	14	Yes	Yes	Yes	

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TABLE 3

Indoor Air Test Results – Undermountain Elementary School, Sheffield, MA – November 2, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
B34	850	70	37	0	Yes	Yes	Yes	Door open
B33	1080	71	34	16	Yes	Yes	Yes	Water damage, door open
C12	1777	71	33	18	Yes	Yes	Yes	Water damage
C13	801	71	31	21	Yes	Yes	Yes	Plastic blocking univent, window open, water damage
C14	1292	71	33	16	Yes	Yes	Yes	Univent blocked, water damage
C16	2017	72	36	17	Yes	Yes	Yes	Water damage
C18	1688	71	34	20	Yes	Yes	Yes	Univent off, water damage
C20	1762	71	34	18	Yes	Yes	Yes	Magazines on univent, water damage
C19	1104	71	33	17	Yes	Yes	Yes	Folders on univent, water damage
Library	792	72	31	4	Yes	Yes	Yes	
Computer Room	1334	73	34	18	No	No	Yes	21 computers, a/c, door open

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Relative Humidity -	40 - 60%

TABLE 4

Indoor Air Test Results – Undermountain Elementary School, Sheffield, MA – November 2, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Music Room	1040	72	33	1	No	Yes	Yes	Univent off, class left ~30 min., door open
Art Room	720	69	30	0	Yes	Yes	Yes	
Greenhouse	533	77	37			No	Yes (4)	Exhaust blocked by paper, standing water
Gym	728	69	34	10+	Yes	Yes	Yes	

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